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Economic analysis and carcasses quality of broiler chickens, fed with *Cajanus cajan*

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The aim of the study was to analyze the economic indicators and carcasses quality of broiler chickens that were fed with *Cajanus cajan*. The work was carried in the beginning (0-4 weeks) and growing-fattening (5-8 weeks) phases, for 56 total day. The animals were divided into three experimental groups (with 6% of flour of roasted seeds of *C. cajan* in diets) and a control group (with based diet on corn and soybean). Three experimental groups were: I, 120 °C for 12 minutes; II, 130 °C for 15 min; and III, 140 °C for 18 min of roasted seeds. Economic analysis estimated for a farm with 2000 animals (500 animals for group). The direct cost accounted between 38.47-43.21%, the value of production and within the elements of direct cost, the highest relative value it had the feeding (between 55.88-57.93%). Any system had economic losses. The bests economic, financial and investment indicators occurred with first experimental group. Total cost/$ USD produced and cost for animal were low, between 0.40-0.45 and $ 4.45-4.67, respectively. Investment recovery period was low, between 7.80-9.72 months. The best weight meager carcass were obtained in the first experimental group with *C. cajan* (2684 g), with the animal should be least amount of fat cover. The performance of the cold carcass was lower in that group, but it had the best use to energy and protein, for produce meager carcass. It proved to be possible to replace 6% of corn and soy in the diet of broilers chicken, for flour *C. cajan* seeds, roasted at 120 ° C for 12 min and obtain favorable economic, financial, investment indicators and production of meager carcasses.

Keywords: cost, performance, Pigeon pea, poultry

INTRODUCTION

Cajanus cajan L. is a plant native to tropical Africa. This plant is a shrub legume rich in protein and other nutrients. She ranks fifth in world production of grain legumes. India is the largest producer of *C. cajan* (Mula and Saxena, 2010 and Rufini, 2014). The high prices of corn and soybeans (ASERCA, 2015) affect the cost of feeding broilers. This

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forces us to look for alternatives, to support the upbringing, without affecting sales prices (Herrera, 2014). *C. cajan* can be used to replace a portion of soybeans in feed for chickens and obtain favorable production results (Sourokou, 2014 and Polyana *et al*., 2014).

C. cajan has antinutricionales factors (ANF), non-nutritive compounds or bioactive nutritionally. These FAN have toxic effects that reduce palatability, digestion and absorption of nutrients (Elizalde *et al*., 2009). Among ANF *C. cajan* stand protease inhibitors and plant lectins. These ANF are destroyed with increasing temperature (Navarro *et al*., 2014 and Bracho *et al*., 2014). The roasted seeds of *C. cajan* reduce their FAN. It is necessary to study, if they could improve the economic performance and carcasses quality of fattening chickens with the replacement of part of corn and soybeans, for seeds roasted *C. cajan* at different times and temperatures.

The aim of the study was to analyze the economic, financial and investment indicators and carcasses quality of broiler chickens that were fed with inclusion of flour of roasted seeds of *C. cajan*.

MATERIALS AND METHODS

Study type

An explanatory study of differences between groups was performed with attribution of causes and experimental randomized block design, to analyze the effect on economic indicators and broiler chicken carcasses, fed with *C. cajan* during the period from September to October, 2014, in the experimental farm "La María" State Technical University of Quevedo (UTEQ), Quevedo, Los Rios province, Republic of Ecuador, to 01° 06' south latitude and 79° 29' west longitude, 75 meters above sea level, with an average temperature of 24.70 °C, relative humidity of 87%, average annual rainfall of 2613 mm, annual heliophany of 886 hours and clay loam soil.

METHODS

With data from the experimental results of productive behavior (table 1) and carcasses quality the analysis was carried out. 170 broilers (50% of each sex) with 50 g of average weight and one day old to the weight of the sale (35 animals for group) were used. The work was carried in the beginning (0-4 weeks) and growing-fattening (5-8 weeks) phases, for 56 total day. The animals were divided into three experimental groups (with 6% of flour of roasted seeds of *C. cajan* in diets) and a control group (with based diet on corn and soybean). Three experimental groups were: I. 120 °C for 12 minutes; II. 130 °C for 15 min; and III. 140 °C for 18 min of roasted seeds. Economic, financial and investment analysis estimated for a farm with 2000 animals (500 animals for group), according to the working capacity of a poultry worker, was performed.

The animals were vaccinated against Newcastle (Life, Guayaquil, Ecuador) on arrival at the facility. It was placed under heating, the initial seven days. These heaters were connected four hours before arrival of the animals. They were housed in rustic facilities and raised in floor with a bed of 15 cm chip. They received once daily ration and had free access to water and food, with artificial night lighting. Each breeding lasted 56 days, plus 10 days of cleaning and restocking of supplies and animals, for the next breeding, with 5.53 production cycles per year.

Cost sheets were performed by production system for calculating the indicators of economic and financial feasibility and investment, where the live weight was the only item. The chips were composed of: fixed costs (depreciation of equipment and installations), variable costs (included food, health, wages, maintenance and other variable costs), indirect production costs (electricity and water) and investment (pay of the animals). Depreciation by linear method ((cost of the asset - value residual)/ year of the asset)) was calculated. The analysis was conducted in US dollars (USD). Wages and prices corresponded to those used in Ecuador.

The percent distribution of direct costs to total costs and production value was effected and economic indicators were calculated: cost/animal, cost/animal/day, unit cost, cost/$ produced, production value, value benefit/cost, profit or economic loss, net income/animal, economic gain/animal, economic gain/kg final live weight and total cost/total final kg live weight produced. The financial indicators net margin, net margin/animal, net margin/kg final live weight and relative net/direct cost income were evaluated, according to Gargano *et al*. (1997). Indicators of investment appraisal economic sensitivity, break-even values, investment payback period and internal rate of return (IRR) were determined, as FIRA (1998) and plotting performed investment indicators were made.

The animals were fasted 12 hours before being sacrificed only with access to drinking water. The evaluation of indicators of sacrifice and carcass quality was performed. The animals were weighed prior to sacrifice (live weight final). Death was performed by the method bled from the jugular vein (Sanchez, 1990). The percentages of cold carcass yield on the weight of hot carcass were evaluated. The hot carcass weight was measured three hours after slaughter of chickens. The cold carcass weight was measured 24 hours after storage at 4 °C). The viscera weight, relative to the weight of the hot carcass; coverage fat cold carcass weight; efficiency of energy and final protein diet to produce leaner carcasses, total cost of production of lean carcasses were measured.

Table 1. Information production and nutrition indicators for feeding systems.

Feeding system indicators	Corn and soybean basal diet	120 °C for 12 min	130 °C for 15 min	140 °C for 18 min
Average daily weight gain, g	54.55	62.79	54.20	37.43
Live body weight in 56 day, g	3105	3566.43	3085	3175
Total feed conversion, g	2.32	2.20	2.43	2.28
Total consumption of food, g	8644.18	8557.04	8883.62	9509.96
Input of ME*, MJ/kg	13.05	12.97	12.97	12.97
Input of CP*, %	18.36	18.47	18.45	18.43

*Metabolic energy and *Crude protein of final diet in phase II of growing-fattening (5-8 weeks).

Table 2. Proportion of elements of direct cost to total cost and value of production of feeding systems for broiler chickens, that were fed with flour roasted seeds of *C. cajan* (6%) or diet using corn and soybeans.

Feeding systems	Elements of direct cost to the total, %				Direct cost to the value of production, %
	Feeding	Animals	Salaries	Others	
Corn and soybean basal diet	56.13	21.46	16.04	6.37	42.34
120 °C for 12 min	57.93	20.58	15.38	6.11	38.47
130 °C for 15 min	56.73	21.17	15.82	6.28	43.21
140 °C for 18 min	55.88	21.58	16.13	6.41	41.16

Statistical analysis

Data were analyzed by SAS software (Statistical Analysis System), version 9.3 (*2013*) to evaluate descriptive statistics (mean) and multiple range test (Duncan, 1955) was used to compare means, in the analysis of variance (ANOVA).

RESULTS

The direct cost accounted between 38.47-43.21%, the value of production and within the elements of direct cost, the highest relative value it had the feeding, followed by animals buy, salaries and other costs, respect the total cost, in all cases (table 2).

Any system had economic losses. The bests economic indicators occurred with flour roasted seeds of *C. cajan* (6%) to 120 °C for 12 min (table 3). It is necessary to emphasize the lowest daily cost for animals, for kilogram and dollar produced in this system was allowed by the animals productive performance (table 1).

The best financial indicators were obtained in broiler chickens that consumed flour roasted seeds of *C. cajan* (6%) to 120 °C for 12 min (table 4). Through net income ratio for direct costs we show that first experimental group had the best use of direct capital.

The most favorable investment indicators were with flour shrub though, with *C. cajan* roasted seeds to 120 °C for 12 min (table 5). It should be noted that the recovery time of investment was low about 7.80 months. In this evaluation we showed that with similar values of fixed costs, economic breakeven was lose with 120 °C for 12 min, when the variable cost items (table 3), improved the area of economic profit.

The best weight meager carcass were obtained in the first experimental diet with *C. cajan* roasted seeds to 120 °C for 12 min, with the animal should be least amount of fat cover (table 6). The performance of the cold carcass was

Table 3. Main economic indicators (USD) feeding systems for broiler chickens, that were fed with flour roasted seeds of *C. cajan* (6%) or diet using corn and soybeans.

Economic indicators, $	Feeding systems			
	Corn and soybean basal diet	120 °C for 12 min	130 °C for 15 min	140 °C for 18 min
Gain or economic loss	2884.41	3551.11	2820.96	3012.82
Net income/animal	10.25	11.77	10.18	10.48
Economic gain/kg total final live weight produced	1.86	1.99	1.83	1.90
Benefit/cost ratio	2.29	2.52	2.24	2.35
Total cost/$ produced	0.44	0.40	0.45	0.42
Economic gain/animal	5.77	7.10	5.64	6.03
Total cost/kg total final live weight produced	1.44	1.31	1.47	1.40
Total feed cost / kg of final live weight gain	0.80	0.75	0.83	0.77
Cost/animal	4.48	4.67	4.54	4.45
Cost/animal/day	0.08	0.08	0.08	0.08

Table 4. Key financial indicators (USD) feeding systems for broiler chickens, that were fed with flour roasted seeds of *C. cajan* (6%) or diet using corn and soybeans.

Financial indicators, $	Feeding systems			
	Corn and soybean basal diet	120 °C for 12 min	130 °C for 15 min	140 °C for 18 min
Net margin	3384.61	4051.31	3321.16	3513.02
Net income ratio/direct cost	2.31	2.55	2.27	2.38
Net margin/kg final weigh	2.18	2.27	2.15	2.21
Net margin/animal	6.77	8.10	6.64	7.03

lower in that group but whit the best use to energy and protein for produce meager carcass.

DISCUSSION

All systems are characterized by the low percentage of direct costs from the value of production (table 3). According to Peña *et al*. (2004), that value which should represent 60% of production cost. The biggest category of direct costs were the feed. This result was favorable and lower than Trómpiz *et al*. (2007) and Trómpiz *et al*. (2010) who stressed that the cost of feeding chickens accounted for between 65-80% of the total cost of production. Replacing a part of corn and soybeans for *C. cajan* in feed for chickens allowed reducing feed costs.

With the study of the main economic indicators the viability of using 6% of flour roasted to 120 °C for 12 min seeds of *C. cajan* was demonstrated (Table 3). Zambrano and Zambrano (2014) obtained lower cost benefit ratio (1.73), but including 5% of seed flour of *C. cajan*. Chambilla (2012) got the best cost benefit ratio (1.43-1.48) using the *C. cajan*, 20% and 15% inclusion in the diet of chickens and the best economic gain ($ 1118.63) to 20% of inclusion. Labrador and Andara (2012) obtained the greatest economic benefit ($ 3400.11 USD) for fattening chickens with the use of *C. cajan*. This value was lower than in our experiment because it was used 20-50% of inclusion in the diet.

Amaefule *et al.* (2011) obtained a total feed cost/ kg of final live weight gained from $ 1.26, but with the inclusion of 30% of *C. cajan*. Arias *et al.* (2010) obtained a cost benefit ratio of 1.01, lower than this research, but they using *C. cajan* in 40% inclusion. The results were higher than Herrera and Ramírez (2006) (with a benefit-cost ratio

Table 5. Main indicators of investment (USD) feeding systems for broiler chickens, that were fed with flour roasted seeds of *C. cajan* (6%) or diet using corn and soybeans.

Investment indicators	Feeding systems			
	Corn and soybean basal diet	120 °C for 12 min	130 °C for 15 min	140 °C for 18 min
Economic sensitivity, kg of live weight	23.99	22.39	24.38	23.49
Investment recovery period, months	9.48	7.80	9.72	9.12
Economic breakeven, $	79.18	73.87	80.44	77.52
Internal rate of return (IRR), %	43.75	44.90	43.61	44.01

Table 6. Indicators of broiler chicken carcasses that were fed with flour roasted seeds of *C. cajan* (6%) or diet using corn and soybeans.

Carcasses indicators	Feeding systems			
	Corn and soybean basal diet	120 °C for 12 min	130 °C for 15 min	140 °C for 18 min
Cold carcasses, %	83.09	77.84	90.44	85.04
Viscera, respect to body weight, %	17.00	12.62	14.85	13.17
Fat cover, respect to cold carcass, %	5.35	3.31	3.94	3.04
Weight meager carcass average, g *	2442^{c}	2684^{a}	2680^{a}	2618^{b}
Efficient use of the energy of the final diet to produce meager carcasses, MJ/kg	5.34	4.83	4.84	4.95
Efficiency of the final protein diet, to produce meager carcasses, g/kg	75.18	68.82	68.84	70.40

* Different letters in superscripts of the means (standard error 0.08) indicate significant differences, p <0.0232 (Duncan, 1955)

of 1.29), but these authors used 40% of flour roasted seeds of *C.cajan*.

In evaluation of financial and investment indicators for feeding systems we probed that best margin net and investment recovery period were obtained using 6% of flour roasted seeds *C. cajan* to 120 ° C for 12 min (tables 4 and 5). This important marginal and investment result was due to higher income and higher final live weight was obtained in the first experimental group. Iorgyer *et al.* (2009) had the best economic margins with increase the level inclusion of *C. cajan* seeds were boiled for 30 minutes, sun dried and then coarsely milled before incorporation into the diets, from 25-75%. They also recommended the use of some method of seed treatment before its incorporation into the diet of chickens. Kperegbeyi and Ikperite (2009) determined that in general, economic indicators were improved and the cost was reduced by feeding chickens diets containing *C. cajan* raw, boiled or soaked, but no differences in the cost for kilogram.

By study of indicators of carcasses the feeding system with *C. cajan* feasibility was demonstrated (table 6). Polyana *et al.* (2014) obtained similar performance cold carcasses (77%) with 5% of *C. cajan*. However, they obtained the lowest value of fat to 15% inclusion. The yield of the carcasses obtained for Yisa *et al.* (2010), of 67.86%, was lower than in this investigation, but they used 20% inclusion of boiled seeds. Iorgyer *et al.* (2009) with *C. cajan* seeds boiled for 30 min, sun dried and then coarsely milled before incorporation into the diets obtained 67.83% but they used 25%.

CONCLUSIONS

It proved to be possible to replace 6% of corn and soy in the diet of broilers chicken, for flour *C. cajan* seeds, roasted at 120 °C for 12 min.

The direct cost accounted between 38.47-43.21%. Total cost/$ USD produced and cost for animal between 0.40-0.45 and $ 4.45-4.67, respectively. Investment recovery period was between 7.80-9.72 months. The bests weight meager carcass (2684 g), use of energy and protein, for produce meager carcass and economic, financial, investment indicators occurred with flour *C. cajan,* roasted at 120 °C for 12 min.

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